



(11) **EP 1 500 904 B1**

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention
of the grant of the patent:
29.09.2010 Bulletin 2010/39

(51) Int Cl.:
G01B 11/24 (2006.01) B21C 37/08 (2006.01)

(21) Application number: **03719173.1**

(86) International application number:
PCT/JP2003/005168

(22) Date of filing: **23.04.2003**

(87) International publication number:
WO 2003/093761 (13.11.2003 Gazette 2003/46)

(54) **METHOD OF AND DEVICE FOR MEASURING BEAD CUTTING SHAPE OF ELECTRIC WELDED TUBE**

VERFAHREN UND EINRICHTUNG ZUR MESSUNG DER BÖRDELUNGSSCHNEIDEFORM EINER ELEKTRISCH GESCHWEISSTEN RÖHRE

PROCEDE ET DISPOSITIF DE MESURE DE LA FORME DE LA COUPE D'UN TUBE SOUDE ELECTRIQUEMENT

(84) Designated Contracting States:
DE FR

(30) Priority: **30.04.2002 JP 2002128497**
29.08.2002 JP 2002251269
24.09.2002 JP 2002277802
29.11.2002 JP 2002348649

(43) Date of publication of application:
26.01.2005 Bulletin 2005/04

(73) Proprietor: **JFE Steel Corporation**
Tokyo, 100-0011 (JP)

(72) Inventors:
• **KODAMA, Toshifumi,**
c/o JFE R & D Corporation
Kawasaki-shi,
Kanagawa 210-0855 (JP)
• **SUZUKI, Taira,**
c/o JFE Steel Corporation
Tokyo,
Tokyo 100-0011 (JP)

- **TORAO, Akira,**
c/o JFE R & D Corporation
Kawasaki-shi,
Kanagawa 210-0855 (JP)
- **TAKEMURA, Yasumasa,**
c/o JFE Steel Corporation
Tokyo,
Tokyo 101-0011 (JP)
- **OKABE, Takatoshi,**
c/o JFE Steel Corporation
Tokyo,
Tokyo 100-0011 (JP)

(74) Representative: **Grünecker, Kinkeldey,**
Stockmair & Schwanhäusser
Anwaltssozietät
Leopoldstrasse 4
80802 München (DE)

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Description

[0001] The present invention relates to a method of and a device for measuring welded bead cutting shapes in an electric resistance welded pipe, including the position of the bead according to the preamble of, respectively, claims 1 and 3.

1. Description of the Related Art

[0002] In general, electric resistance welded pipes, such as electric resistance steel pipes, are manufactured by continuously forming steel plates or steel coils into a tubular form, and continuously performing butt welding both sides of the steel coil in the longitudinal direction by means such as high-frequency induction heat-pressure welding or resistance heat-pressure welding.

[0003] A raised portion called a "bead" is formed at the weld portion of the electric resistance welded pipe due to the butt welding, on the inside of the pipe and the outside of the pipe. Generally, the bead is continuously cut in the longitudinal direction of the steel pipe by a cutting tool on the production line further downstream from the welder. The shape of the surface of the pipe after the bead portion has been cut off (hereafter referred to as "bead cutting shape") preferably becomes one with the outline shape of the pipe other than the weld, such that where the bead was cannot be distinguished, ideally. In order to achieve this, the cutting tool tip must be held at an appropriate position on the surface of the electric resistance welded pipe.

[0004] Conventionally, a worker has measured the bead cutting shape, visually or using a micrometer or the like, at the time of starting cutting, and adjusted the cutting tool to the optimal position. However, there have been cases wherein, while manufacturing a number of electric resistance welded pipes, the position of the cutting tool shifts due to a variety of reasons, the blade of the cutting tool is nicked, etc., causing defective cutting such as not all of the bead being cut off of the electric resistance welded pipe product or cutting too deep. Such cutting defects not only mar the look of the electric resistance welded pipe product; using electric resistance welded pipes with cutting defects for piping subjected to pressure such as gas lines or the like may place the pipe at risk of rupturing.

[0005] Accordingly, there is the need to measure and monitor the bead cutting shape while manufacturing, and suitably correct the cutting tool position or replace the cutting tool with a new one, according to the results thereof.

[0006] Even with regard to the outer face of the pipe which is readily observed from the outside, monitoring of the bead cutting shape has to depend on visual observation of workers, so precision and reproducibility thereof is insufficient, and there have been quantitative and reliability problems.

[0007] With regard to the inner face of the pipe, the bead cutting portion cannot be directly observed during manufacturing, due to the configuration of the production line. Accordingly, the end portion of the pipe is observed at the process where the pipe is cut at the end position of the line. Alternatively, the line is stopped to cut out a sample of the bead position of the pipe by gas cutting, and the inner face is observed. With the former method, the observation position is several tens of meters downstream from the cutting position, so there has been a problem in that in the event that an abnormality occurs in the cutting, the defective pipe becomes longer until detected, resulting in decrease in yield. Also, with the later method, the cutting tool seizes due to friction heat in the event that the line is stopped, so the cutting tool must be retracted. Resetting the cutting tool and restarting the line creates a step between the previously-cut bead cutting shape and the new cutting shape, so that portion is unusable as a product. There has been the problem that productivity decreases due to stopping the line for taking the sample. Only a part in the longitudinal direction of the product can be inspected in both of the above-described methods, so there has been the problem that the quality cannot be guaranteed for the entire length of the product.

[0008] An Example of an optical cutting method and device as defined in the preamble of claims 1 and 3, respectively, is disclosed in the Japanese Patent Application Laid-open Publication No. JP 06241740.

[0009] Japanese Patent Application Laid-open Publication No. JP 03289505 discloses a three dimensional shape measuring device and measuring method. Said device comprises a lamp irradiating light through a condenser lens, a liquid-crystal shutter and a projecting lens to a surface of a body to be measured M. Said device further comprises a camera having an image sensing element on which an image of the surface of the body is focussed. An output of the camera is submitted to a CPU by an A/D converter and an interface to obtain a luminance distribution data of the body. A pattern control part switches the shutter based on the command from the CPU, and the body is irradiated with the total light. The image is picked up with the camera. The image signal from the camera is received in the CPU, and the luminance distribution data are obtained. The fringe-shaped luminance distribution data are corrected, and the shape of the body is determined and displayed on a surface-shape displaying device.

[0010] European Patent Application Laid-open Publication No. EP 0 532 257 A2 refers to a weld bead quality determining apparatus. Said apparatus determines the quality of the weld bead of an welded assembly of different metal sheets by projecting obliquely a slit beam of light on the weld bead to make an illuminated band on an upper surface of the welded assembly. A CCD camera disposed above the welded bead photographs the illuminated band to make an

image of the illuminated band. The image is treated in an image pre-treatment device so that a surface of a transverse cross section of the weld bead can be expressed in the form of one-dimensional data. Characteristics of the cross section of the weld bead are extracted from the one-dimensional data and are compared with predetermined references in a personal computer so that it is determined whether the weld bead is acceptable.

[0011] In order to solve the problems, a bead cutting shape measurement method using the optical cutting method has been further proposed. Examples of the optical cutting method are disclosed in Japanese Unexamined Patent Application Publication No. 57-108705 and Japanese Examined Patent Application Publication No. 60-1138. As shown in Fig. 13, slit light 121 from a light source 120 is cast on a measuring object (electric resistance welded pipe 110), and this is observed from a different angle with a camera 130, thereby observing a slit image (optical cutting image) deformed following the surface shape of the measuring object 110. The shape of the object can be calculated from this optical cutting image and the geometric position of the observation optical system.

This is advantageous in that the observation optical system is simple, that the measurement sensitivity can be widely changed according to the geometric placement of the observation optical system, and so forth. The region outside of the irradiation region of the slit light is called "background texture".

[0012] Japanese Unexamined Patent Application Publication No. 52-96049 proposes a bead shape observation method wherein an uncut weld bead portion is observed with the optical cutting method, and marks corresponding to an enlargement ratio determined by optical placement on a display monitor 140.

[0013] However, these methods only display a measurement image. Judgment of the bead cutting shape is performed by workers visually judging the monitor 140, and automatic measurement is not yet employed.

[0014] An example of a determination method for automatic measurement is the technique disclosed in Japanese Patent No. 2618303, for example. According to this, a method is proposed wherein a picture is taken of the steel pipe bead cutting portion using an optical cutting image from slit light and an ITV camera at the time of measuring the shape following cutting the welding bead of the electric resistance welded pipe, and as shown in Fig. 13, the cross-sectional shape is calculated by performing thinning processing (taking a region wherein one pixel is connected in one direction as a thin line) on the cross-sectional shape picture, the cut portion and uncut portion are distinguished by the luminance of the cross-sectional shape, the value for the center of the distinguished cut portion and the value at the right edge of the cut portion and the value at the left edge of the cut portion are obtained, and the cutting depth, and amount of cutting inclination are calculated based on these three calculated values.

[0015] However, with the technique disclosed in Japanese Patent No. 2618303, the specific method for thinning processing only involves performing computation for directly substituting luminance to Y-axis coordinates, such as plotting the maximum luminance in a direction parallel to the pipe axis (Y-axis direction) obtained from the optical cutting image onto the coordinates on an X axis extending in the circumferential direction of the pipe (this is equivalent to the width direction for material steel plates and steel coils, and accordingly with hereafter be referred to as the width direction), so there is the problem in that there are cases wherein an accurate cross-sectional shape cannot be obtained.

[0016] Describing this in detail, from the experience of the Inventors repeating experiments at the manufacturing site, while the surface of the cut portion of the electric resistance welded pipe immediately following cutting has a specular surface, the surrounding uncut portions are blackish due to an oxide layer adhering thereto, so the degree of diffusion of the slit light thereof differs. Accordingly, the luminance of the optical cutting image of the bead cutting portion is not necessarily around the same degree in the width direction. For example, there are cases such as in Fig. 14 wherein almost all of the slit light of the cut portion exhibits specular reflection (reflection in the opposite direction to the incident direction at the same angle as the incident angle), with the luminance thereof being one-tenth or less than that of the uncut portion. This is due to the fact that in the event that the incident angle and the reception angle differ, such specular reflection light actually appears to have less luminance.

[0017] In such cases, the optical cutting image becomes lost in noise, so the bead cutting shape cannot be obtained well. Attempting to raise the luminance of the cut portion by raising the gain or extending the exposure time of the observation optical system of the ITV camera or the like leads to exceeding the range of the maximum luminance of the specifications of the observation optical system such as the aforementioned camera or the like (halation) at the uncut portion as indicated by (c) in Fig. 1, so the shape of the uncut portion cannot be accurately distinguished. The reason is that in the event that such exceeding of the range of luminance occurs, multiple pipe axis direction coordinates (Y-axis coordinates) indicating the maximum luminance appear at the uncut portion on the optical cutting image, and the pipe axis direction coordinates (Y-axis coordinates) indicating the maximum luminance cannot be uniquely determined.

[0018] The present invention has been made to solve the problems such as described above, and accordingly, it is an object thereof to provide a method and device for precisely measuring the bead cutting shape of electric resistance welded pipe without being affected by the difference in luminance level between the cut portion and uncut portion in optical cutting images.

[0019] With regard to suppressing the effects of noise in such an optical cutting method, proposals in other fields using the optical cutting method are conventionally known.

[0020] Japanese Patent Application Laid-open Publication No. JP 11271029 relates to a measuring apparatus of a

three dimensional form which reduces a number of storage devices and which is hard to be effected by noise. Said apparatus comprises an irradiation device which performs the scanning of slit light to a measurement target object, a camera performing the image pick-up of the target object using the radiated slit light and a calculating device computing the three-dimensional image data based on the obtained image of the camera. The camera is provided with a light receiver which performs the multiple array of a scanning line in a pixel row. A peak detector detects and specifies the maximum brightness to which the image pick-up of the camera is performed to the cross direction, for every scanning line. A pixel position detector specifies the horizontal address of the pixel with the specified maximum brightness.

[0021] Japanese Unexamined Patent Application Publication No. 57-208404 proposes a method wherein an optical cutting image is searched vertically from top to bottom and an optical cutting line is extracted only from within a section wherein a portion greater than a predetermined setting value first occurs, and subsequent extraction of optical cutting lines is terminate at the one scanning line, thereby preventing erroneously detecting abnormal reflections at portions of the optical cutting line on the object other than the slit luminescent line position.

[0022] Also, Japanese Unexamined Patent Application Publication No. 2-35306 proposes a shape detecting method wherein the entire region of the acquired optical cutting image is scanned in the direction crossing the optical cutting line, and in the event that there is a peak value due to the noise image on the scanning line, an optical cutting search range is set based on the optical cutting line position detected on the same scanning line over the entire screen, thereby ignoring noise.

[0023] Also, Japanese Unexamined Patent Application Publication No. 4-240508 proposes a three-dimensional shape recognition device for calculating coordinates of an object of measurement based on an optical cutting image, and judging the image to be an unreal image in the event that the shape thereof exists in a needle-like shape separated from surrounding images, thereby ignoring that data and recognizing the shape.

[0024] However, with the method disclosed in Japanese Unexamined Patent Application Publication No. 57-208404, a fixed threshold V1 is used for recognizing the only optical cutting extraction section, so application thereof to measuring bead cutting shapes wherein the luminance of the optical cutting line of the acquired optical cutting image changes greatly between the cut portion and uncut portion is impossible, as already described.

[0025] Also, the method disclosed in Japanese Unexamined Patent Application Publication No. 2-35306 assumes that parts having raised shapes with a generally uniform size in the longitudinal direction are arrayed in the direction of the slit light at equal intervals, as with soldered portions of electronic parts, and generation of noise is explained as being secondary light due to reflected slit light off of a neighboring part, so this is clearly inapplicable to the problems of the present invention since a similar noise generation state is not generated at the cut portion of an electric resistance welded pipe.

[0026] Also, with the technique disclosed in Japanese Unexamined Patent Application Publication No. 4-240508, in the state that the optical cutting image of the cut bead becomes non-continuous at a step portion, the step portion is erroneously recognized as a non-continuous image (unreal image) and ignored, so there has been the problem that this could lead to missing cutting defects.

[0027] That is to say, no method has yet been found in the Technical Field of the Present Invention or the field of shape recognition techniques by optical cutting in other Technical Fields, for accurately measuring weld bead cutting shapes even in the event that the SN ratio between the optical cutting line image and the surroundings deteriorates.

[0028] The present invention has been made to solve the above-described problems, and accordingly it is an object thereof to provide a measurement method and measurement device which can readily recognize image processing abnormality portions due to deterioration in the SN ratio in three-dimensional shape measurement by the optical cutting method as being uneven portions due to cutting.

SUMMARY OF THE INVENTION

[0029] Accordingly, it is an object of the present invention to provide a measurement method and device for bead cutting shapes which enable highly precise measurement and detection in manufacturing of electric resistance welded pipes.

[0030] In order to attain the above objectives, there is provided a method of measuring a bead cutting shape of an electric resistance welded pipe as defined in claim 1 and a device for measuring a bead cutting shape of an electric resistance welded pipe as specified in claim 3.

[0031] Further preferred embodiments of the method and the device are subject to the dependent claims, respectively.

[0032] According to the present invention, the bead cutting shape of electric resistance welded pipe can be precisely measured without being affected by the difference in luminance level between the cut portion and uncut portion in optical cutting images. The features of the electric resistance welded pipe bead shape are calculated based on the shape data of the pipe surface, so the bead shape can be detected without being affected by changes in the magnetic permeability of the welded portions. The bead shape can be accurately detected even in cases wherein the bead slopes are extremely smooth or the bead height is low, in cases wherein the height of the bead is irregular in the longitudinal direction, or in

cases wherein the bead shape is not a triangle or trapezoid, or in cases wherein the bead shape is steep. Also, the bead cutting shape data can be automatically computed and recorded, so not only is the optical cutting image visually monitored; rather, combining this with quantitative judgement and understanding inclinations, and further cutting position control, enables advanced electric resistance welded pipe manufacturing operations to be carried out.

BRIEF DESCRIPTION OF THE DRAWINGS

[0033]

Figs. 1A through 1C are diagrams illustrating the operations of the present invention;
 Fig. 2 is a flowchart illustrating a calculating method for an optical cutting line according to a first explanatory arrangement of the present invention;
 Fig. 3 is a flowchart illustrating a calculating method for an optical cutting line according to a second explanatory arrangement of the present invention;
 Fig. 4 is a schematic diagram illustrating an inner face bead trimmer comprising a bead cutting shape measurement device for an electric resistance welded pipe according to the present invention;
 Fig. 5 is a block diagram illustrating the configuration of principal components of the bead cutting shape measurement device according to the present invention;
 Fig. 6 is a diagram illustrating an optical cutting image measurement example of a bead cutting portion of an electric resistance welded pipe according to a first embodiment of the present invention;
 Fig. 7 is a diagram illustrating the bead cutting shape of the electric resistance welded pipe output by an image reconfiguring circuit of the first embodiment with regard to the measured image shown in Fig. 6;
 Fig. 8 is a diagram illustrating an example wherein a shape abnormality has been observed in the output of the first embodiment at the time of manufacturing a different electric resistance welded pipe;
 Fig. 9 is a diagram illustrating the results of collecting a sample of the bead cutting portion on the inner side of the pipe equivalent to Fig. 8, and performing off-the-line measurements of the bead cutting shape;
 Fig. 10 is a block diagram illustrating the configuration of principal components of the bead cutting shape measurement device according to a second embodiment of the present invention;
 Fig. 11 is a diagram illustrating optical cutting image measurement results of the bead cutting portion of the electric resistance welded pipe according to the same;
 Fig. 12 is a diagram illustrating the bead cutting shape of the electric resistance welded pipe output by an image reconfiguring circuit of the second embodiment with regard to the measured image shown in Fig. 11;
 Fig. 13 is a schematic diagram illustrating the principle of optical cutting method;
 Fig. 14 is a diagram illustrating an example wherein a portion of the luminance of the optical cutting image has markedly deteriorated, in the event of measuring the bead cutting portion of the electric resistance welded pipe with the optical cutting method;
 Fig. 15 is a schematic diagram illustrating an inner face bead trimmer comprising a bead cutting shape measurement device for an electric resistance welded pipe according to the present invention;
 Fig. 15 is a schematic diagram illustrating the principle of optical cutting method;
 Fig. 16 is a diagram illustrating an example wherein a portion of the luminance of the optical cutting image has markedly deteriorated in the event of measuring the bead cutting portion of the electric resistance welded pipe with the optical cutting method;
 Fig. 17 is a diagram illustrating an example wherein a halation is observed at the uncut portion in the event of raising the luminance of the cut portion;

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0034] The following is a detailed description of embodiments of the present invention, with reference to the drawings.

[0035] First, two explanatory arrangements will be given as examples of embodiments of the present invention, for the purpose of explaining the principle of the present invention, following which the First Embodiment and subsequent embodiments will be described.

[0036] In a case of taking an optical cutting image with two-dimensional image-taking means such as a CCD camera, a region having both background texture and a slit light irradiation region can be expected to be displaced on a display screen. This will hereafter be referred to as an "optical cutting image". In an optical cutting image, the optical cutting image of the slit light irradiation region is captured as a two-dimensional mesh display image such as shown in Fig. 1A. In Fig. 1A, with the corner further to the bottom left of a bottom left corner pixel sectioned by the two-dimensional mesh as the origin, and with the X axis in the width direction and the Y axis in the pipe axial direction, a diagonal line center can be taken for a representative point for the pixel at the lower left corner, with the coordinates thereof as $X = X_1$, and

Y = Y1. Accordingly, each pixel can be determined by coordinates X = Xi, Y = Yj.

[0037] Let us say that the aforementioned optical cutting image displays an optical cutting image of the slit light irradiation region including the background texture, and for a given pixel represented by the X coordinate X = Xi and the Y coordinate Y = Yj in the optical cutting image, the luminance at that pixel is I(Xi, Yj).

[0038] Let us further take the weighted mean S(Xi) of the Y coordinate Yj and luminance I(Xi, Yj) as defined in the following expression as the Y coordinates on the optical cutting line at X = Xi.

$$S(X_i) = \sum Y_j I(X_i, Y_j) / \sum I(X_i, Y_j)$$

[0039] Now, in the event that there is a disturbance component such as indirect reflection light or background light in the portion outside of the irradiation region of the slit light, such as the background texture portion shown in Fig. 1B, this component will also be added, resulting in error, but the maximum luminance in the Y-axial direction in the optical cutting image is the slit light irradiation region with little expansion in the Y-axial direction, the extent of which can be described beforehand. The range of Y coordinates in the portion outside of the slit light irradiation region can be taken as noise.

[0040] Accordingly, the Y coordinates of the optical cutting line at each X coordinate is obtained by the following procedures (1) through (3).

- (1) The Y coordinate Y0 where the Y-axial direction luminance is the greatest (in the event that multiple coordinates exist, the average thereof), and the luminance I0 at that point, are obtained.
- (2) The maximum luminance I1 in the range of

$$0 \leq Y \leq Y_0 - N_w \Delta Y, Y_0 + N_w \Delta Y \leq Y \leq Y_n$$

wherein Yn is a representative Y coordinate of a pixel at the Y-directional edge of the optical cutting image, and ΔY represents the Y-directional length of one pixel, is obtained, using a predetermined number of pixels, denoted by Nw.

(3) An appropriate value between I0 and I1 (e.g., an average value (I0 + I1)/2) is set as a threshold value J1, and S(Xi) is calculated in the range of Y wherein the pixel luminance in the Y direction is greater than J1.

(4) The above procedures (1) through (3) are repeated with the relative movement of the slit light irradiation region in the pipe axial direction.

[0041] The procedures for the Y coordinate calculation method for the optical cutting line according to this first explanatory arrangement are shown as a flowchart in Fig. 2, and such computation allows the optical cutting image of the bead cutting shape of the electric resistance welded pipe to be precisely measured without being affected by difference in the luminance level at the cut portion and uncut portion of the optical cutting image.

[0042] Also, in the event that the intensity of the reflected light at the uncut portion further causes halation such as indicated by the whited-out portion in Fig. 1A, that is to say, in the event that the intensity of the reflected light at the uncut portion is high enough to exceed the luminance measurement range as shown in Fig. 1C, or, in the event that the noise from the background texture portion is low enough to be negligible, cross-section line calculation of regions with such high reflection light intensity may be substituted with a predetermined fixed threshold value J2. That is to say, the following procedures may be followed instead of the above-described procedures.

- (1) The Y coordinate Y0 where the Y-axial direction luminance is the greatest (in the event that multiple coordinates exist, the average thereof), and the luminance I0 at that point, are obtained.
- (2) The maximum luminance I1 in the range of

$$0 \leq Y \leq Y_0 - N_w \Delta Y, Y_0 + N_w \Delta Y \leq Y \leq Y_n$$

wherein Yn is a representative Y coordinate of a pixel at the Y-directional edge, and ΔY represents the Y-directional length of one pixel, is obtained, using a predetermined number of pixels, denoted by Nw.

(3) In the event that I0 is equal to or exceeds the fixed threshold value J2, S(Xi) is calculated in the range of Y wherein the pixel luminance in the Y direction at X = Xi is equal to or greater than J2.

In this case, J2 may be set to be the maximum value of the luminance range, or may be set somewhat lower than the maximum value of the luminance range, in the range shown by experience not to be equal to or lower than the maximum luminance of the background texture portion.

(4) In the event that 10 is less than the fixed threshold value J2, an appropriate value between 10 and I1 (e.g., an average value $(10 + I1)/2$) is set as a threshold value J3 (equivalent to J1 in the first explanatory arrangement), and S(Xi) is calculated in the range wherein the pixel luminance in the Y direction is greater than J3.

(5) The above procedures (1) through (4) are repeated with the relative movement of the slit light irradiation region in the pipe axial direction.

[0043] The procedures for the Y position calculation method for the optical cutting line according to this second explanatory arrangement are shown as a flowchart in Fig. 3, and such computation allows the optical cutting image of the bead cutting shape of the electric resistance welded pipe to be precisely measured without being affected by difference in the luminance level at the cut portion and uncut portion of the optical cutting image.

[0044] The slit light irradiation image, which is a pseudo-cross-sectional shape image so as to say, on the electric resistance welded pipe is thus calculated using the optical cutting method. Now, the X coordinate and Y coordinate of the optical cutting line representing the slit light irradiation image with a weighted mean in the slit width direction are the pixel address of the optical cutting image, and in the example of the two explanatory arrangements described above, this is a set of two values with the lower left corner of the optical cutting image as the origin (0, 0), which can be readily converted into a full-scale true cross-sectional shape of the electric resistance welded pipe bead cutting shape.

[0045] That is to say, defining the direction perpendicular to both the pipe axis and the width direction as having a 0° directional angle, with the incident angle of the light source as α and the receiving angle of the image-taking means as β and further with slit light for the light source and with a camera serving as the image-taking means, in a case wherein a plane formed by the optical axis of the slit light and the optical axis of the camera is disposed perpendicular to the tangential plane of the electric resistance welded pipe at the image-taking position, the cross-sectional position (xi, yj) on the image can be converted by geometric formula into coordinates (xi, yj) for the full-scale true cross-sectional shape of the electric resistance welded pipe bead cutting shape by the expressions

$$xi = Xi$$

$$yj = \Delta Y \times Yj \times \cos \alpha / \sin(\alpha + \beta)$$

wherein ΔY represents the length of one pixel in the y direction.

[0046] Or, an arrangement may be used wherein a sample wherein dimensions are already known is taken, and conversion coefficients are adjusted from (Xi, Yj) to (xi, yj), instead of the above expression.

[0047] In electric resistance welded pipe manufacturing, the width of the welding bead before cutting is around 1/10 to 1/5 of the outer diameter of the pipe, and the position where the welding bead is can be generally known beforehand. The reason is that with general electric resistance welded pipe manufacturing lines, the metal strip which is the material uninterruptedly continues from uncoiling of the metal strip coil of base material, through the formation and welding stages of the pipe, and the position and direction thereof is restricted by the formation rolls and so forth, so even in the event that horizontal movement of the pipe (change in path line), twisting, etc., does occur, the maximum extent thereof is around the width of the bead or so. Here, the bead portion may be anywhere on the circumference of the pipe, but the following descriptions will be made with the bead portion at around the top of the pipe, to facilitate description. Of course, this assumption does not diminish the generality thereof in any way.

[0048] Now, detecting the pipe shape including the bead portion over a range sufficiently wider than the bead width (hereafter referred to as "profile of electric resistance welded pipe") with an appropriate method and approximating the detected profile of the electric resistance welded pipe with a quadratic function, the approximation curve attempts to approximate not only the base pipe portion but also the protruding shape of the bead portion thereupon at the same time, so the curve is a curve which passes above the profile of the base pipe portion and below the apex of the bead portion. This curve is a first approximation curve. Now, the general apex position Xc of the bead portion can be obtained with separate means, and points X1 and Xr where the first approximation curve and the profile of the electric resistance welded pipe intersect can be obtained by searching to the left and right from the general apex position, thereby obtaining a general bead range R (X1' to Xr') from the coordinates of X1, Xr, and Xc.

[0049] Now, the first approximation curve is restricted to a quadratic function. The reason is that, while the shape of the pipe is essentially horizontally symmetrical with regard to the apex of the bead portion, so approximation with an

even function such as a polynomial of an even degree should suffice, approximation with a quartic polynomial or higher showed that inflection points are generated on the approximation curve which accentuate the bead portion, causing adverse effects with regard to calculation of the intersecting points with the base pipe portion. Accordingly, using only a quadratic function avoids this problem.

[0050] Next, performing approximation of the profile of the range excluding R at the width-direction coordinate (X coordinate) with a polynomial of an even degree, quadratic or higher, the shape of the base pipe portion can be approximately quite precisely. This is a second approximation curve.

[0051] The basis for this is shown in the graph in Fig. 39, which indicates the relation between the degree of the polynomial and the RMS (root-mean-square) of the approximation error in the event that the curve at the upper half of an ellipse is subjected to regression with quadratic, quartic, sextic, and octic polynomials. This indicates that regression of the shape of the ellipse can be made with sufficient precision by a polynomial of an even degree, quadratic or higher, and preferably with a polynomial of an even degree, quartic or higher.

[0052] This nature can be used to compare the profile of the base pipe portion approximately with sufficient precision with the profile of the electric resistance welded pipe including the bead portion, so as to determine the region containing the coordinates of the bead apex in the range wherein the deviation of the profiles is greater than a predetermined threshold to be the bead.

[0053] The above computation uses a polynomial as the approximation curve, so using the least-square method allows regression computation to be performed simply with addition, multiplication, and matrix computation. That is to say, none of the assumptions of circularity and differential computations and the like which have been problematic with the conventional art are used, so there are no effects of noise, and also, complicated procedures such as moving averages for noise removal or noise data removal operations per coordinate are unnecessary.

Embodiments

[0054] The following is a description of embodiments of the present invention, with reference to the drawings.

(First Embodiment)

[0055] Fig. 4 illustrates around a bead trimmer 112 on the inner face of the electric resistance welded-pipe 110, with reference numeral 114 denoting a cutting tool, 116 denoting a supporting arm, 150 denoting a measurement head of a bead cutting shape measurement device according to the present invention, 170 denoting a control device, 190 denoting a display device, and 192 denoting a recording device.

[0056] The measurement head 150 is placed downstream in the pipe transportation direction of the cutting tool 114, preferably at a position 500 to 2000 mm therefrom, preferably has a mechanism for protecting the measurement equipment from radiant heat and welding sparks from the welding seam, and scattering of cooling water, and preferably has a gas purging mechanism handling both cleansing and cooling, in order to prevent overheating of the optical system and soiling thereof by water, oil, fumes, and so forth.

[0057] Also, the control device 170, display device 190, and recording device 192 are preferably positioned at a working position away from the manufacturing line, for example, near an operating board not shown in the drawings to be operated by an operator, and connected to the measurement head 150 by a cable 160 through a supporting arm 116 or the like, with a shielded configuration to prevent intrusion of electric noise or the like along the way.

[0058] Now, while the description of the following embodiment will be made regarding a configuration for measuring the bead cutting shape on the inner side of the pipe, it is needless to say that the measurement method and device for the electric resistance welded pipe bead cutting shape according to the present invention may be equally applied to the outer face or the inner face of the pipe.

[0059] Next, the configuration of the measurement head 150 and the control device 170 will be described with reference to Fig. 5. In Fig. 5, reference numeral 120 denotes a slit light source, 130 denotes a CCD camera, 132 denotes a lens, 124 denotes light source power source, 134 denotes camera power source, and 172 denotes an image data conversion circuit.

[0060] Here, the light source power source 124, camera power source 134, image data conversion circuit 172, and the later-described computation circuit group are preferably stored in one case as a control device 170. The computation circuit group is a first computation circuit 174, a second computation circuit 176, an integration circuit 178, an image reconfiguring circuit 180, and a coordinates computation circuit 182.

[0061] The slit light source 120 is within the measurement head 150 and irradiates a slit light 121 which has an angle α as to the cross-section of the electric resistance welded pipe 110, has a predetermined irradiation width in the pipe circumferential direction (width direction), and forms the irradiation weight of a rectangular irradiated image as narrow as possible in the pipe axial direction, preferably 0.05 mm or less, and in this aspect, the present embodiment has the same arrangement as with conventional art.

[0062] Now, arrangements using a semiconductor laser device of the light-emitting unit are widely used for the slit light, and arrangements using a combination of knife-edge screens and cylindrical lenses or the like to make the irradiated image rectangular are commercially available.

[0063] Also, the closer this angle α is to 90° , the more the bead cutting shape observed with the later-described camera 130 is expanded in the pipe axial direction, but at the same time increases the effects of distance fluctuations between the measurement head 150 and the inner face of the pipe, so the present embodiment uses $\alpha = 70^\circ$ as a suitable value taking the balance of both into consideration, based on prior experiments.

[0064] The camera 130 observes the irradiation image of the slit light irradiated onto the bead cutting portion from an angle β as to the cross-section of the electric resistance welded pipe 110, and ITVs or cameras using semiconductor devices such as CCD or CMOS which are widely used in industrial fields can be used. Also, a commercially-available camera lens may be used for the lens 132 for image formation by the camera, but a bandpass filter having a passage wavelength band matching the wavelength of the light source in order to eliminate unnecessary light such as background light or the like from the optical cutting image, and a heat-ray cut filter or the like for preventing damage to the image-taking surface of the camera and the lens from radiant heat, should be provided as necessary.

[0065] The measurement head 150 is preferably a sealed structure for protecting the optical equipment such as the camera 130, light source 120, lens 132, etc., within from heat and water and the like, and in this case, a preferably configuration has windows 152 and 154 for only the slit light and camera field of view portions, respectively.

[0066] The position angle of the camera 130 is preferably such that $(\alpha + \beta)$ is generally 90° , with the number of pixels of the camera and the field of view being determined based on the width of the bead portion and the necessary resolution. With the present invention, the slit light irradiation angle from the light source 120 is $\alpha = 70^\circ$, the image-taking angle is $\beta = 30^\circ$, the range of the field of view is 25 mm wide and 20 mm high, and the number of pixels is 1300 horizontally by 1000 vertically, as a suitable value. Thus, the height-wise resolution is $20/1000 \cdot \cos(70^\circ) / \sin(70^\circ + 30^\circ) = 0.0069$ mm. Also, the width-wise resolution is $25/1300 = 0.0192$ mm, so the bead cutting state can be monitored with a resolution of $20 \mu\text{m}$ in the width direction (circumferential direction) and $7 \mu\text{m}$ in the height direction (pipe axial direction).

[0067] Also, it is needless to say that the light source 120 and camera 130 should be positioned such that the optical axes thereof intersect precisely over the bead cutting portion, and further, the plane formed by the axial axes of the light source 120 and camera 130 even more preferably contains the direction of progression of the electric resistance welded pipe 110, i.e., the center axis of the pipe. The reason is that this arrangement of the light source and the camera allows the optical cutting image on the inner face of the pipe to be horizontally symmetrically taken with regard to a virtual center line extending in the Y-axial direction on the optical cutting image.

[0068] Further, the light source 120 and the camera 130 may be fixed to the measurement head 150 in an inclined state as shown in Fig. 5, or may be disposed so that their optical axes are both parallel to the central axis within the electric resistance welded pipe to reduce the size of the device, with the angle of the optical axis being changed by the reflection mirror 136.

[0069] Next, the configuration of the components of the control device 170 will be described. The image data conversion circuit 172 converts each pixel of image signals output from the camera 130 into luminance data and outputs, and an image board (frame-grabber) widely commercially available in recent years, which is compatible with the camera 130, can be used.

[0070] The first computation circuit 174 is for calculating the maximum luminance I_0 in the Y-axial direction and the Y coordinate Y_0 showing the maximum luminance, for each X coordinate X_i ($i = 0$ through N) in the acquired image, and the second computation circuit 176 is for calculating the maximum luminance I_1 of the background texture in the pixel data in the Y-axial direction ($0 \leq Y \leq Y_0 - N_w \Delta Y$, $Y_0 + N_w \Delta Y \leq Y \leq Y_n$), using Y_0 and the number of offset pixels set beforehand N_w and the Y-directional length of one pixel ΔY . The second computation circuit 176 may have the same configuration as the first computation circuit 174, except for the computation range being different.

[0071] The integration circuit 178 calculates a threshold value J_1 by a predetermined internal division ratio from the I_0 and I_1 thus calculated, and calculates the weighted mean $S(X_i)$ only in the range wherein, of one line pixel in the Y direction wherein $X = X_i$, the pixel luminance is greater than J_1 . With the present embodiment, the internal division ratio is $1 : 1$, so this is calculated by $J_1 = (I_0 + I_1)/2$.

[0072] The image reconfiguring circuit 180 reconfigures the weighted mean $S(X_i)$ output for each X coordinate as described above into an image picture $Q(X_i, Y_j)$ as optical cutting shapes at each $X = X_i$.

[0073] The coordinates computation circuit 182 converts a string of optical cutting line coordinates (a set of an X coordinate and a Y coordinate indicating the position of the optical cutting line at each X coordinate) output by the image reconfiguring circuit 180 based on a predetermined conversion expression determined by the placement of the optical system and the resolution of the camera, into the full-scale data of a true cross-sectional shape, and can be realized with a circuit which performs computation of (x_i, y_j) , described in the section on operations, for example.

[0074] Next, the results of implementing the present embodiment will be described.

[0075] An optical cutting image, observed with the camera 130 through the lens 132 from the slit light 121 irradiated from the light source 120 of this device onto the bead cutting portion 111 while manufacturing the electric resistance

welded pipe 110, was as shown in Fig. 6, with the slit light irradiation image being bright and heavy at the uncut portion, and the slit light irradiation image at the cut portion being difficult to visually recognize.

[0076] On the other hand, the image output from the image reconfiguring circuit 180 is as shown in Fig. 7, and even though the contrast of the optical cutting image was extremely low at the cut portion, the fact that the cut was normal, and the manner in which the cut portion and uncut portion differ in curvature, could be observed. Also, the output image of the image reconfiguring circuit 180 while manufacturing a different electric resistance welded pipe 110 was as shown in Fig. 8, wherein it could be configured that the bead cutting was incomplete, due to some sort of cutting abnormality. A sample was collected of the bead cutting portion on the inner side of the pipe equivalent to Fig. 8, and off-the-line measurements were performed using a non-contact distance meter, which showed that the height of the step at the incompletely cut portion was 0.15 mm as shown in Fig. 9, thereby confirming that the bead cutting shape is being measured accurately even in cases wherein there are abnormalities in the cutting.

(Second Embodiment)

[0077] Fig. 10 is a block diagram illustrating the configuration of the computation circuit group within the measurement head according to another embodiment of the present invention. The unshown bead trimmer 112 and measurement head 150 to be mounted thereupon are of the same configuration as those in the first embodiment, so description thereof will be omitted.

[0078] Also, in Fig. 10, with regard to the first computation circuit 174, second computation circuit 176, integration circuit 178 (hereafter referred to as "first integration circuit"), and image reconfiguring circuit 180, the same articles as those used in the above first embodiment may be employed here. Reference numeral 184 in the present embodiment denotes a branch circuit and 186 denotes a second integration circuit.

[0079] The branch circuit 184 is a circuit for judging which of the maximum luminance 10 on the optical cutting line calculated by the first computation circuit 174, and the fixed threshold value J2 set beforehand, is greater, and causing one or the other of the first integration circuit 178 and the second integration circuit 186 to operate. This can be configured with a commercially-available comparator circuit.

[0080] The first computation circuit 174 is for calculating the maximum luminance 10 in the Y-axial direction and the Y coordinate Y0 showing the maximum luminance, for each X coordinate Xi (i = 0 through N) in the acquired image, the branch circuit 184 is a circuit for judging whether or not the maximum luminance 10 is greater than the predetermined fixed threshold value J2, and the second integration circuit 186 calculates the weighted mean S(Xi) only in the range wherein, of one line pixel in the Y direction wherein the pixel luminance is greater than the predetermined fixed threshold value J2. With the present embodiment, the threshold J1 of the integration circuit 178 in the above-described first embodiment is replaced with the predetermined fixed threshold value J2.

[0081] The same image reconfiguring circuit 180 as that with the above-described first embodiment may be used, with the branch circuit 184 selecting either the first integration circuit 178 or the second integration circuit 184 as the input thereof.

[0082] Next, the results of implementing the present embodiment will be described.

[0083] An optical cutting image of the bead portion on the inner face of the electric resistance welded pipe observed with the present embodiment while manufacturing another electric resistance welded pipe 110, was as shown in Fig. 11, with the uncut portion to the right side exhibiting halation so the optical cut line is markedly heavier than other portions, and noise extending upwards and downwards, while the slit light irradiation image at the cut portion is difficult to visually recognize, as with the first embodiment. On the other hand, the image output from the image reconfiguring circuit 180 is as shown in Fig. 12, and the bead cutting shape could be measured suitably without effects of halation or noise.

Claims

1. A method of measuring a bead cutting shape of an electric resistance welded pipe, for measuring the shape following cutting a bead generated on the inner face or outer face of an electric resistance welded pipe at a welding portion, said method comprising:

a step for obtaining an optical cutting image, by taking an image of slit light (121) irradiated on said bead portion with image-taking means (130), from an angle (β) different to the irradiation direction of said slit light (121);

characterized in

that the method further comprises

a step for obtaining each of maximum luminance in the pipe axial direction at a given width-direction coordinate on said optical cutting image, and maximum luminance in background texture region outside of the irradiation range of said slit light; a step for performing interior division of the maximum luminance of said pipe axial direction

and

the maximum luminance of said background texture region by a ratio determined beforehand, and setting the obtained luminance as a threshold value; a step for taking a luminance greater than said threshold value and a weighted mean of pipe axial direction coordinates indicating said luminance as pseudo-cross-sectional direction coordinates for said width-direction coordinates and pipe axial direction coordinates; and
 a step for calculating the bead cutting shape of said electric resistance welded pipe (110) based on a pseudo-cross-sectional shape obtained by stringing pseudo-cross-sectional direction coordinates in the width direction, and a predetermined conversion expression determined from a geometric positional relation of said light source (120) of said slit light (121), said image-taking means (130), and said electric resistance welded pipe (110).

2. The method according to claim 1, **characterized in that** said method comprises subsequent to said step for obtaining an optical image; a step for taking, in the event that the maximum luminance in the pipe axial direction at a given width-direction coordinate on said optical cutting image is equal to or exceeds a predetermined fixed threshold value, a weighted mean of pipe axial direction coordinates indicating said luminance as pseudo-cross-sectional direction coordinates for said width-direction coordinate and pipe axial direction coordinate; and
 that said step for obtaining each of maximum luminance is performed in the event that the maximum luminance is less than the predetermined fixed threshold value.

3. A device (150) for measuring a bead cutting shape of an electric resistance welded pipe, said device (150) comprising:

a slit light source (120) for irradiating slit light (121) at a given incident angle (α) on a bead portion of an electric resistance welded pipe (110) following cutting; and
 image-taking means (130) for taking an irradiation image of said slit light (121) at a different receiving angle (β);

characterized in

that said device (150) further comprises

a first computation circuit (174) for calculating, with regard to the optical cutting image output from said image-taking means (130),

the maximum luminance in the pipe axial direction at a given width-direction coordinate on said optical cutting image, and

the pipe axial direction coordinate where said maximum luminance occurs;

a second computation circuit (176) for calculating the maximum luminance in background texture region, at a position removed by a predetermined number of pixels or more from a pipe axial direction coordinate where said maximum luminance in said pipe axial direction occurs at a given width-direction coordinate;

an accumulation circuit (178) for calculating

a luminance which is greater than a threshold calculated following a predetermined computation expression from said first computation circuit (180) and said second output computation circuit, and

the weighted mean of pipe axial direction coordinates indicating said luminance;

an image reconfiguring circuit for stringing the weighted mean of pipe axial direction coordinates thus calculated to generate a pseudo-cross-sectional shape in the width direction; and

a coordinates computation circuit (182) for calculating and displaying the bead cutting shape of said electric resistance welded pipe (110) based on a predetermined conversion expression determined from a geometric positional relation of said slit light source (120), said image-taking means (130), and said electric resistance welded pipe (110).

4. The device according to claim 3, **characterized in that** the device further comprises a branch circuit (184) for judging whether or not the maximum luminance in the pipe axial direction at said certain width direction is equal to or greater than a predetermined fixed threshold value;

that said accumulation has a first accumulation circuit (178) for calculating the weighted mean of pipe axial direction coordinates greater than a threshold obtained by interior division of the maximum luminance in the pipe axial direction at said certain width direction, and the maximum luminance at background texture region, by a predetermined ratio; and a second accumulation circuit (186) for calculating said luminance equal to or greater than said predetermined fixed threshold value and the weighted mean of pipe axial direction coordinates indicating said luminance; and that said image reconfiguring circuit (180) is provided for selecting the output of said first accumulation circuit (178) and said second accumulation circuit (186) thus calculated following output from said branch circuit (184) and stringing said output in the width direction so as to generate a pseudo-cross-sectional shape.

Patentansprüche

1. Verfahren zur Messung einer Wulstschnittform eines elektrisch widerstandsgeschweißten Rohres, um die Form nach dem Schneiden einer Wulst zu messen, die auf der Innenfläche oder der Außenfläche eines elektrisch widerstandsgeschweißten Rohres an einem Schweißabschnitt entsteht, wobei das Verfahren umfasst:

einen Schritt des Beziehens eines optischen Schneidbildes durch Aufnehmen eines Bildes eines Spaltlichtes (121), das auf den Wulstabschnitt abgestrahlt wird, mit einer Bildaufnahmeeinrichtung (130) aus einem Winkel (β), der sich von der Abstrahlrichtung des Spaltlichtes (121) unterscheidet;

dadurch gekennzeichnet, dass
das Verfahren weiterhin umfasst:

einen Schritt des Beziehens jeweils einer maximalen Luminanz in der Rohrachsrichtung an einer gegebenen Breitenrichtungsordinate an dem optischen Schneidbild und einer maximalen Luminanz in dem Hintergrundtexturbereich außerhalb des Abstrahlbereiches des Spaltlichtes; einen Schritt des Ausführens einer Division der maximalen Luminanz der Rohrachsrichtung und der maximalen Luminanz des Hintergrundtexturbereiches untereinander in einem Verhältnis, das zuvor bestimmt wurde, und Einstellen der erhaltenen Luminanz als einen Schwellenwert; einen Schritt des Wählens einer Luminanz, die größer ist als der Schwellenwert, und eines gewichteten Mittelwertes der Rohrachsrichtungskoordinaten, die die Luminanz kennzeichnen, als Pseudo-Querschnittsrichtungskoordinaten für die Breitenrichtungskoordinaten und die Rohrachsrichtungskoordinaten und einen Schritt des Berechnens der Wulstschnittform des elektrisch widerstandsgeschweißten Rohres (110) auf der Basis einer Pseudo-Querschnittsform, die man durch Aufreihen von Pseudo-Querschnittsrichtungskoordinaten in der Breitenrichtung erhält, und einer vorbestimmten Umwandlungsgleichung, die aus einer geometrischen Positionsbeziehung der Lichtquelle (120) des Spaltlichtes (121), der Bildaufnahmeeinrichtung (130) und des elektrisch widerstandsgeschweißten Rohres (110) bestimmt wird.

2. Verfahren nach Anspruch 1, **dadurch gekennzeichnet, dass** das Verfahren nach dem Schritt des Beziehens eines optischen Bildes umfasst: für den Fall, dass die maximale Luminanz in der Rohrachsrichtung an einer gegebenen Breitenrichtungsordinate an dem optischen Schneidbild größer oder gleich einem vorbestimmten, festgelegten Schwellenwert ist, einen Schritt des Wählens eines gewichteten Mittelwertes von Rohrachsrichtungskoordinaten, die die Luminanz kennzeichnen, als Pseudo-Querschnittsrichtungskoordinaten für die Breitenrichtungsordinate und die Rohrachsrichtungsordinate; und
und **dadurch**, dass der Schritt des Beziehens jeweils der maximalen Luminanz für den Fall ausgeführt wird, dass die maximale Luminanz geringer ist als der vorbestimmte, festgelegte Schwellenwert.

3. Vorrichtung (150) zum Messen einer Wulstschnittform eines elektrisch widerstandsgeschweißten Rohres, wobei die Vorrichtung (150) enthält:

eine Spaltlichtquelle (120), die Spaltlicht (121) mit einem gegebenen Einfallswinkel (α) auf einen Wulstabschnitt eines elektrisch widerstandsgeschweißten Rohres (110) nach dem Schneiden abstrahlt, und
eine Bildaufnahmeeinrichtung (130), die ein Abstrahlbild des Lichtes Spaltlichtes (121) in einem anderen Aufnahmewinkel (β) aufnimmt;

dadurch gekennzeichnet, dass
die Vorrichtung (150) weiterhin enthält:

einen ersten Berechnungskreis (174), der im Hinblick auf das optische Schneidbild, das von der Bildaufnahmeeinrichtung (130) ausgegeben wird, berechnet:
die maximale Luminanz in der Rohrachsrichtung bei einer gegebenen Breitenrichtungsordinate an dem optischen Schneidbild, und
die Rohrachsrichtungsordinate, an der die maximale Luminanz auftritt;
einen zweiten Berechnungskreis (176), der die maximale Luminanz in einem Hintergrundtexturbereich an einer Position berechnet, die um wenigstens eine vorbestimmte Anzahl von Pixeln von einer Rohrachsrichtungsordinate entfernt ist, an der die maximale Luminanz in der Rohrachsrichtung an einer gegebenen Breitenrichtungsordinate auftritt;
einen Akkumulationskreis (178), der berechnet:

eine Luminanz, die größer ist als ein Schwellenwert, der nach einer vorbestimmten Berechnungsglei-

chung von dem ersten Berechnungskreis (180) und dem zweiten Berechnungskreis berechnet wird, und

den gewichteten Mittelwert von Rohrachsrückungskoordinaten, die die Luminanz kennzeichnen; einen Bildneukonfigurationskreis, der den gewichteten Mittelwert von Rohrachsrückungskoordinaten, die auf diese Weise berechnet werden, aufreht, um eine Pseudo-Querschnittsform in der Breitenrichtung zu erzeugen; und

einen Koordinatenberechnungskreis (182), der die Wulstschnittform des elektrisch widerstandsgeschweißten Rohres (110) auf der Basis einer vorbestimmten Umwandlungsgleichung berechnet und anzeigt, die aus einer geometrischen Positionsbeziehung der Spaltlichtquelle (120), der Bildaufnahmeeinrichtung (130) und des elektrisch widerstandsgeschweißten Rohres (110) bestimmt wird.

4. Vorrichtung nach Anspruch 3, **dadurch gekennzeichnet, dass** die Vorrichtung weiterhin einen Verzweigungskreis (184) enthält, der beurteilt, ob die maximale Luminanz in der Rohrachsrückungsrichtung an der bestimmten Breitenrichtung größer oder gleich einem vorbestimmten, festgelegten Schwellenwert ist oder nicht;

dadurch, dass die Akkumulation enthält: einen ersten Akkumulationskreis (178) zum Berechnen des gewichteten Mittelwertes von Rohrachsrückungskoordinaten, die größer sind als ein Schwellenwert, den man durch Division der maximalen Luminanz in der Rohrachsrückungsrichtung an der bestimmten Breitenrichtung und der maximalen Luminanz in dem Hintergrundtexturbereich in einem vorbestimmten Verhältnis untereinander erhält; und einen zweiten Berechnungskreis (186) zum Berechnen der Luminanz aufweist, die größer oder gleich dem vorbestimmten, festgelegten Schwellenwert ist, und des gewichteten Mittelwertes der Rohrachsrückungskoordinaten, die die Luminanz kennzeichnen; und

und **dadurch**, dass der Bildneukonfigurationskreis (180) dazu vorgesehen ist, die Ausgabe des ersten Akkumulationskreises (178) und des zweiten Akkumulationskreises (186), die auf diese Weise berechnet wurden, nach der Ausgabe aus dem Verzweigungskreis (184) zu wählen und die Ausgabe in der Breitenrichtung aufzureihen, um so eine Pseudo-Querschnittsform zu erzeugen.

Revendications

1. Procédé de mesure de la forme de la coupe d'un tube soudé par résistance électrique, destiné à mesurer la forme suite à la coupe d'un cordon formé sur la face interne ou la face externe d'un tube soudé par résistance électrique dans une partie formant soudure, ledit procédé comprenant :

une étape d'obtention d'une image de coupe optique, par la prise d'une image d'une lumière à fente (121) irradiée sur ladite partie formant cordon avec des moyens de prise d'image (130), selon un angle (β) différent de la direction d'irradiation de ladite lumière à fente (121) ;

caractérisé en ce que

le procédé comprend en outre

une étape d'obtention de chacune d'une luminance maximale dans la direction axiale du tube à une coordonnée donnée dans la direction de la largeur sur ladite image de coupe optique, et d'une luminance maximale dans une région de texture de fond située en dehors de la plage d'irradiation de ladite lumière à fente ; une étape de division interne de la luminance maximale de ladite direction axiale du tube et de la luminance maximale de ladite région de texture de fond par un rapport préalablement déterminé, et de fixage de la luminance obtenue comme valeur seuil ; une étape de prise d'une luminance supérieure à ladite valeur seuil et une moyenne pondérée des coordonnées dans la direction axiale du tube indiquant ladite luminance comme pseudo coordonnées dans la direction de la section transversale pour lesdites coordonnées dans la direction de la largeur et coordonnées dans la direction axiale du tube ; et une étape de calcul de la forme de la coupe dudit tube soudé par résistance électrique (110) en se basant sur une pseudo forme de section transversale obtenue par la mise en chaîne des pseudo coordonnées dans la direction de la section transversale, et sur une expression de conversion prédéterminée, définie en fonction d'une relation de position géométrique entre ladite source de lumière (120) de ladite lumière à fente (121), lesdits moyens de prise d'image (130) et ledit tube soudé par résistance électrique (110).

2. Procédé selon la revendication 1, **caractérisé en ce que** ledit procédé comprend, à la suite de ladite étape d'obtention d'une image optique : une étape qui consiste, au cas où la luminance maximale dans la direction axiale du tube à une coordonnée donnée dans la direction de la largeur sur ladite image de coupe optique serait égale ou supérieure à une valeur seuil fixe prédéterminée, à prendre une moyenne pondérée des coordonnées dans la direction axiale du tube indiquant ladite luminance comme pseudo coordonnées dans la direction de la section transversale pour

lesdites coordonnées dans la direction de la largeur et coordonnée dans la direction axiale du tube ; et
en ce que ladite étape d'obtention de chacune des luminances maximales est effectuée dans le cas où la luminance maximale est inférieure à la valeur seuil fixe prédéterminée.

- 5 **3.** Dispositif (150) de mesure de la forme de la coupe d'un tube soudé par résistance électrique, ledit dispositif (150) comprenant :

une source de lumière à fente (120) pour irradier une lumière à fente (121) selon un angle d'incidence donné (α) sur une partie formant cordon d'un tube soudé par résistance électrique (110) suite à la coupe ; et
 10 des moyens de prise d'image (130) pour prendre une image d'irradiation de ladite lumière à fente (121) selon un angle de réception différent (β) ;

caractérisé en ce que

ledit dispositif (150) comprend en outre

un premier circuit de calcul (174) pour calculer, par rapport à l'image de coupe optique produite par lesdits
 15 moyens de prise d'image (130),

la luminance maximale dans la direction axiale du tube à une coordonnée donnée dans la direction de la largeur sur ladite image de coupe optique, et

la coordonnée dans la direction axiale du tube où ladite luminance maximale est observée ;

un second circuit de calcul (176) pour calculer la luminance maximale dans une région de texture de fond, à
 20 une position éloignée d'un nombre prédéterminé de pixels ou plus d'une coordonnée dans la direction axiale du tube où ladite luminance maximale dans ladite direction axiale du tube est observée à une coordonnée donnée dans la direction de la largeur ;

un circuit d'accumulation (178) pour calculer

une luminance qui est supérieure à un seuil calculé en fonction d'une expression de calcul prédéterminée par
 25 ledit premier circuit de calcul (180) et ledit second circuit de calcul de sortie, et

la moyenne pondérée des coordonnées dans la direction axiale du tube indiquant ladite luminance ;

un circuit de reconfiguration d'image pour mettre en chaîne la moyenne pondérée des coordonnées dans la direction axiale du tube ainsi calculées afin de générer une pseudo forme de section transversale dans la direction de la largeur ; et

30 un circuit de calcul de coordonnées (182) pour calculer et afficher la forme de la coupe dudit tube soudé par résistance électrique (110) en se basant sur une expression de conversion prédéterminée, déterminée en fonction d'une relation de position géométrique entre ladite source de lumière à fente (120), lesdits moyens de prise d'image (130) et ledit tube soudé par résistance électrique (110).

- 35 **4.** Dispositif selon la revendication 3, **caractérisé en ce que** le dispositif comprend en outre un circuit de dérivation (184) pour estimer si la luminance maximale dans la direction axiale du tube à ladite certaine direction de largeur est ou non supérieure ou égale à une valeur seuil fixe prédéterminée ;

en ce que ladite accumulation présente un premier circuit d'accumulation (178) pour calculer la moyenne pondérée des coordonnées dans la direction axiale du tube supérieure à un seuil obtenu par division interne de la luminance
 40 maximale dans la direction axiale du tube à ladite certaine direction de largeur, et de la luminance maximale dans une région de texture de fond, par un rapport prédéterminé ; et un second circuit d'accumulation (186) pour calculer ladite luminance supérieure ou égale à ladite valeur seuil fixe prédéterminée et la moyenne pondérée des coordonnées dans la direction axiale du tube indiquant ladite luminance ; et **en ce que** ledit circuit de reconfiguration d'image (180) est prévu pour sélectionner la sortie dudit premier circuit d'accumulation (178) et dudit second circuit d'accumulation (186) ainsi calculée suite à la sortie dudit circuit de dérivation (184) et pour mettre en chaîne ladite sortie
 45 dans la direction de largeur de manière à générer une pseudo forme de section transversale.

FIG. 1

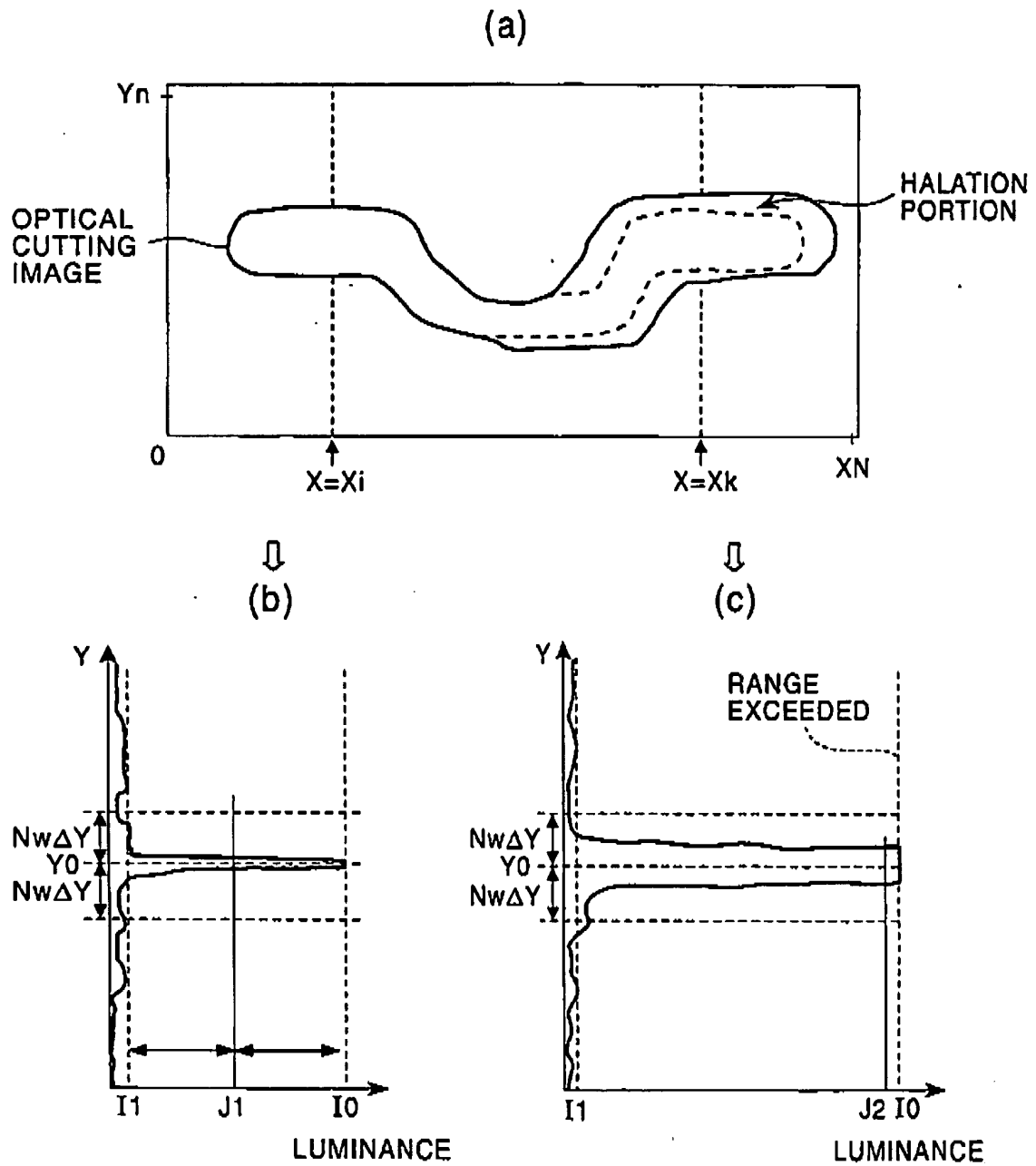


FIG. 2

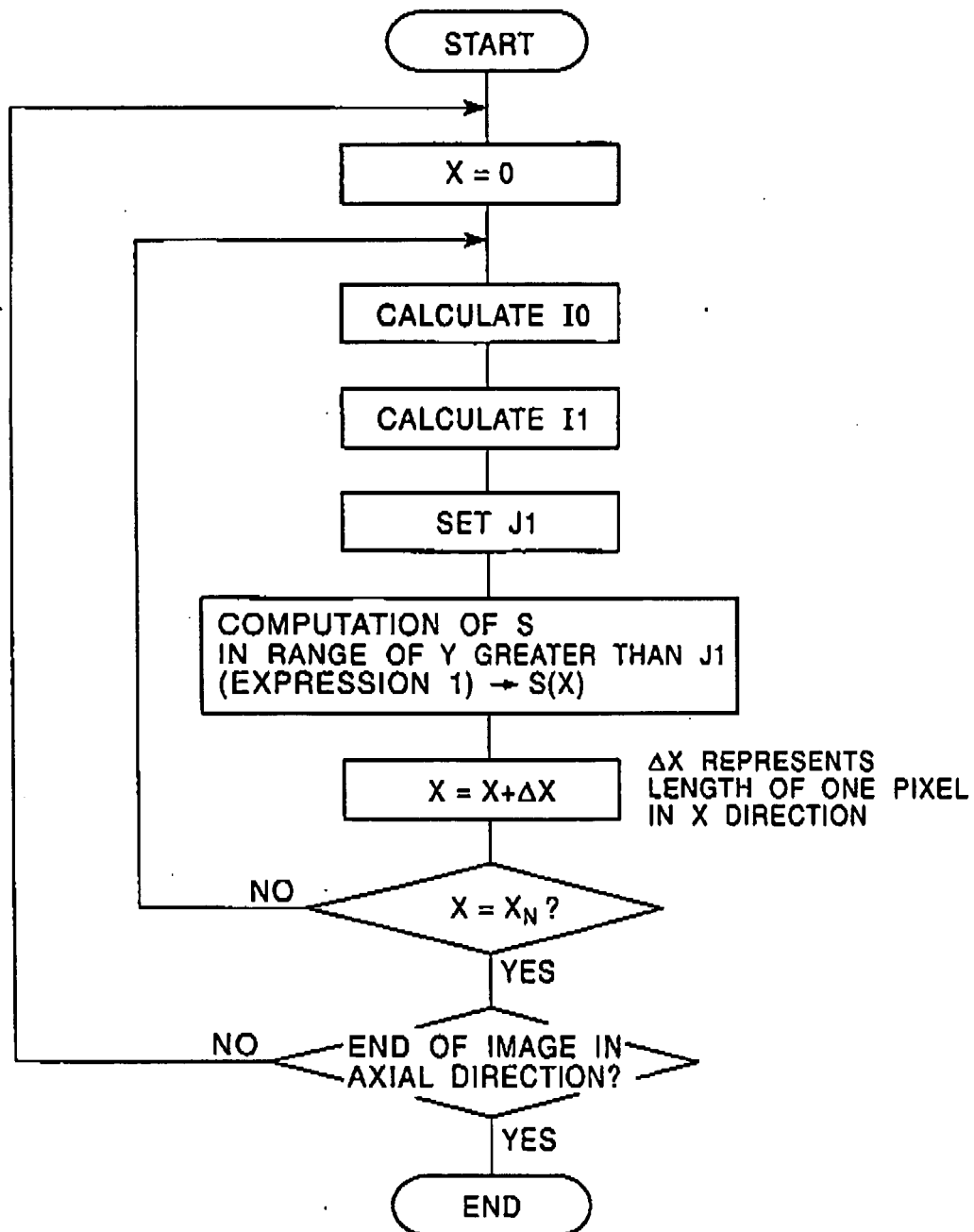


FIG. 3

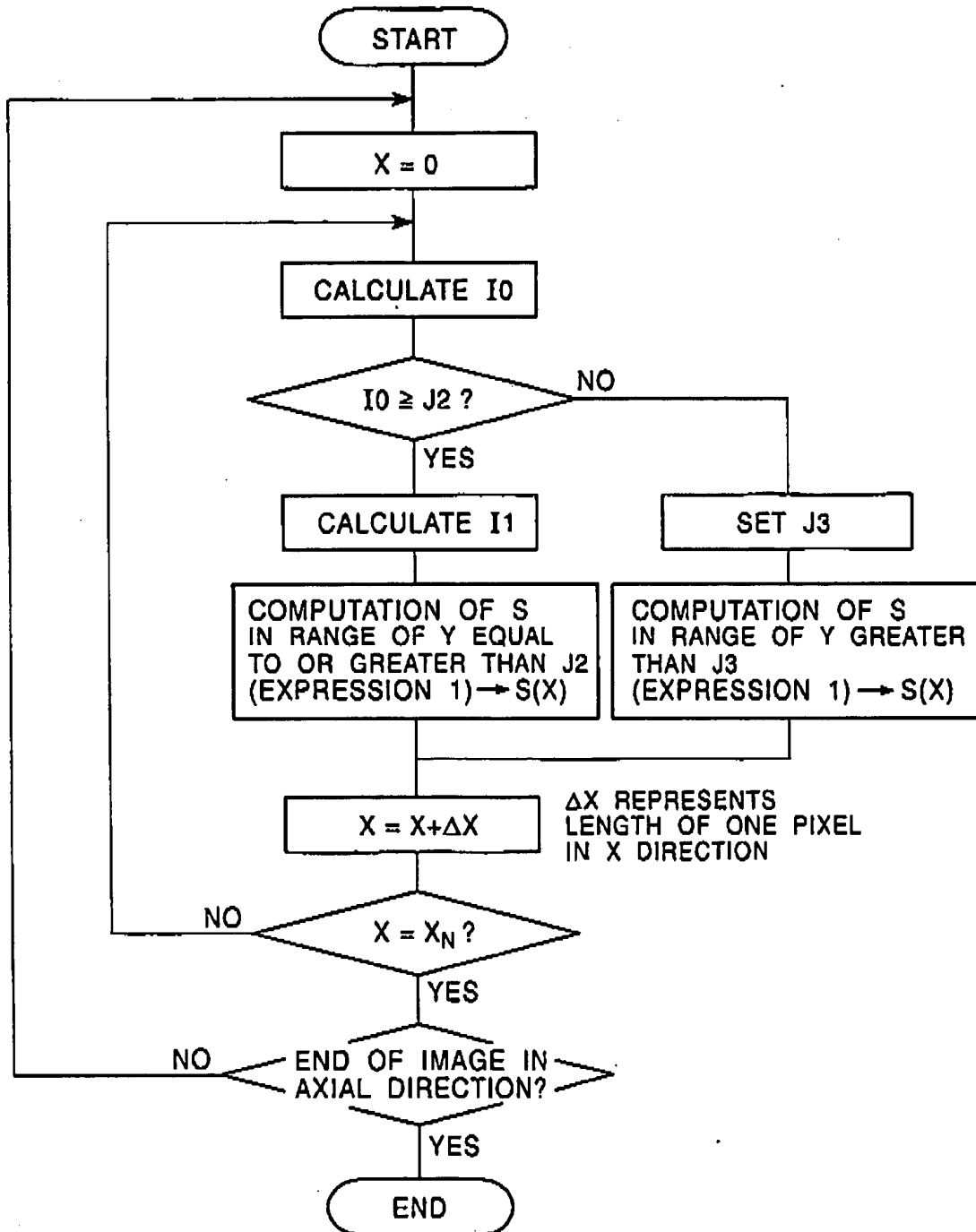


FIG. 4

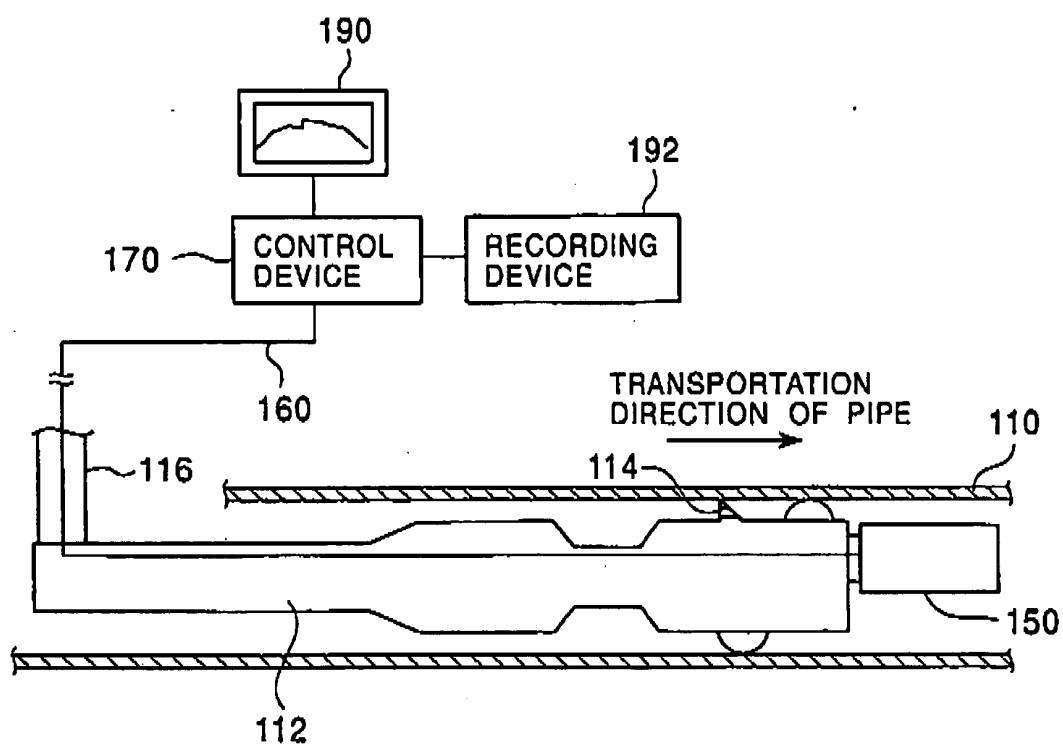


FIG. 5

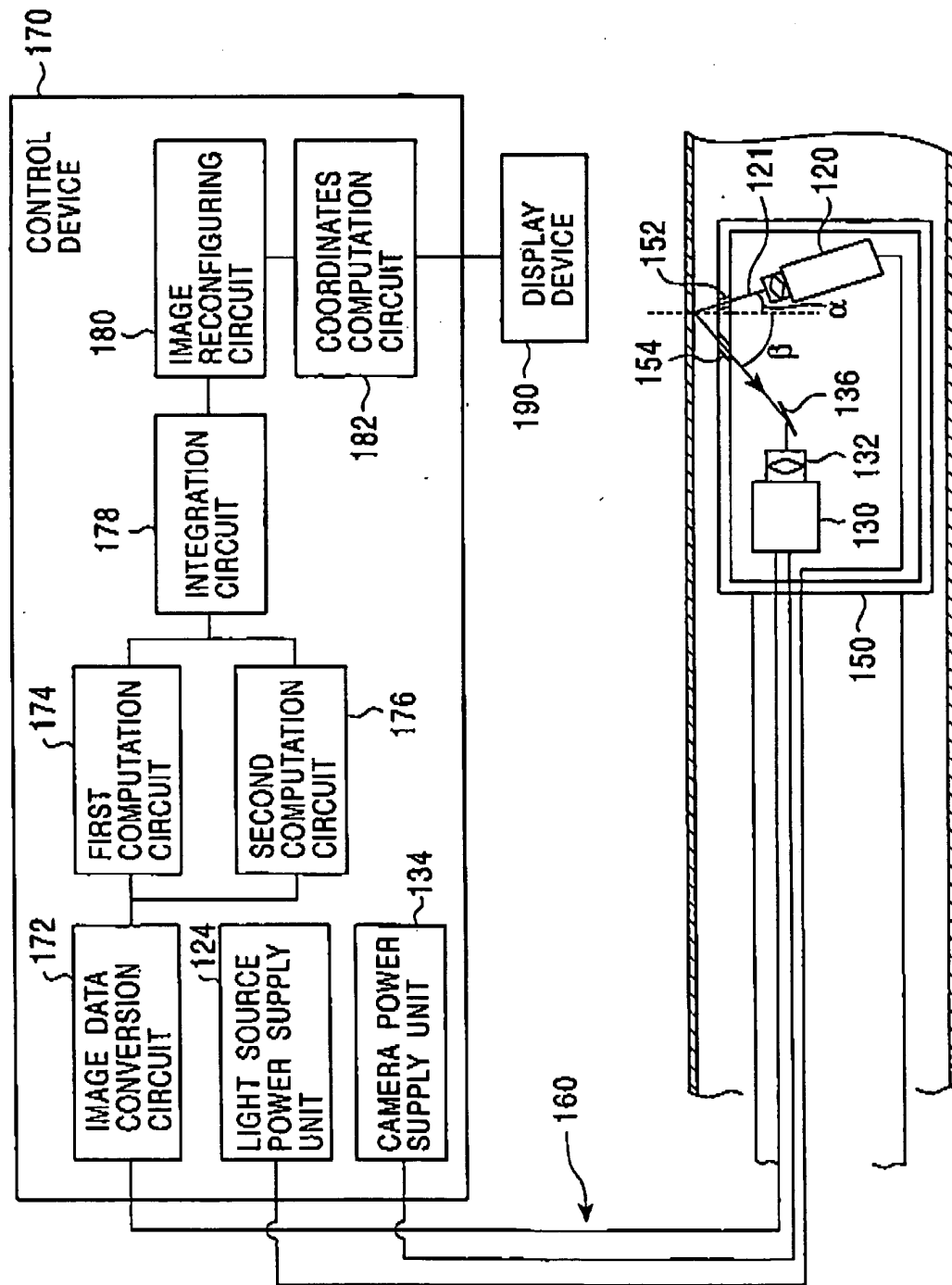


FIG. 6

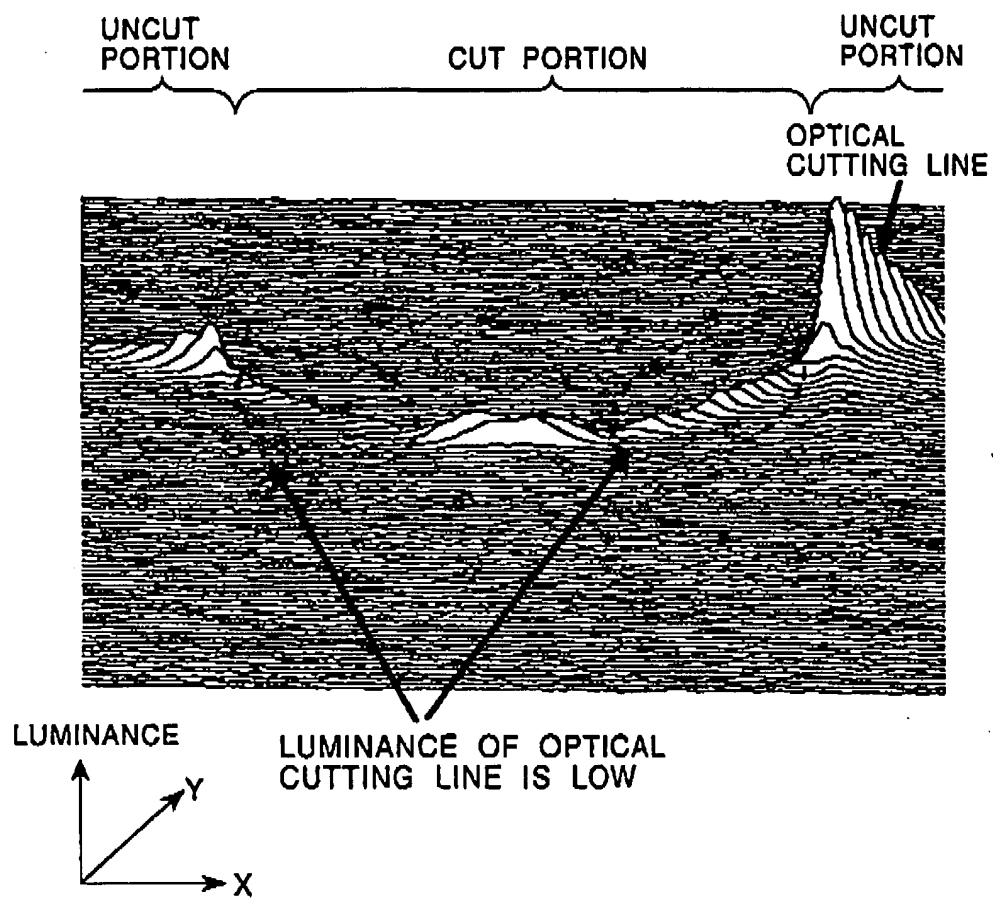


FIG. 7

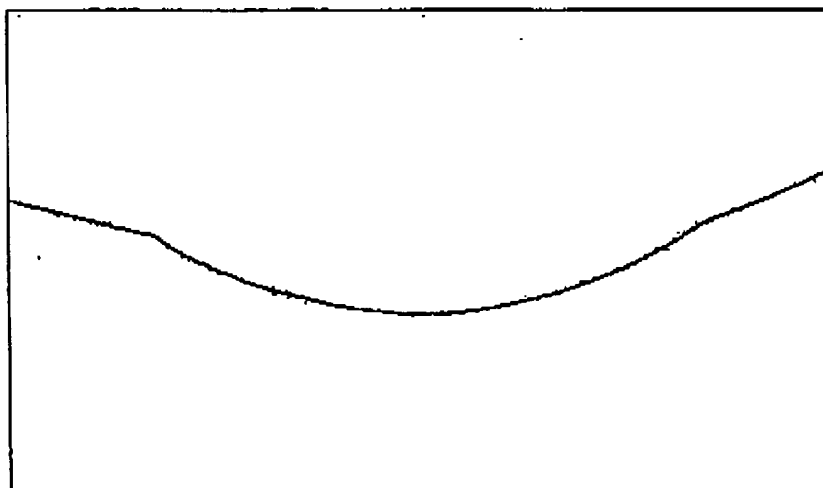


FIG. 8

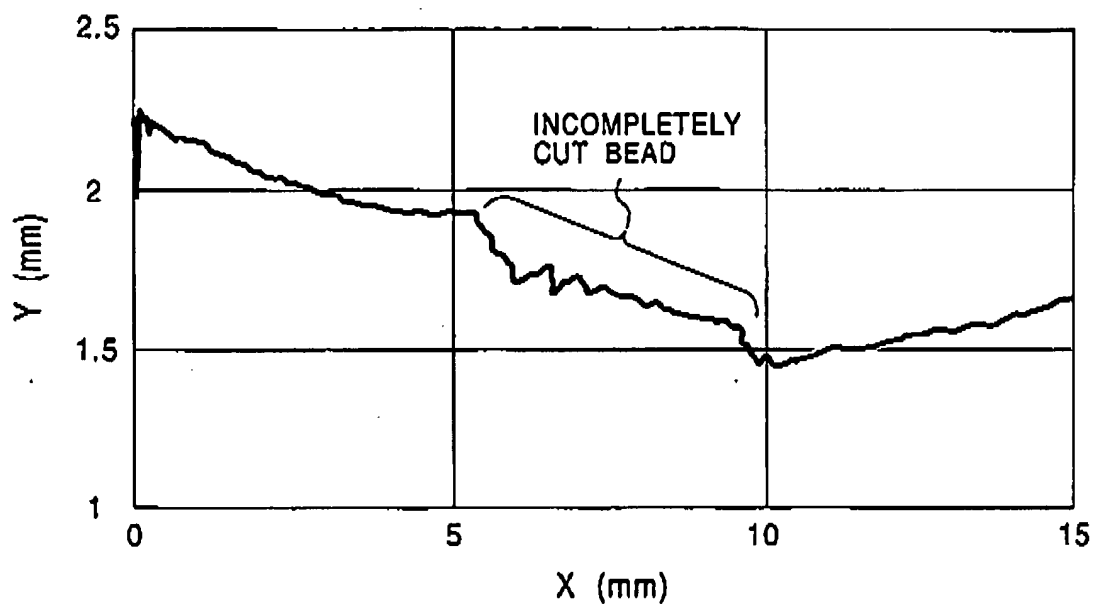


FIG. 9

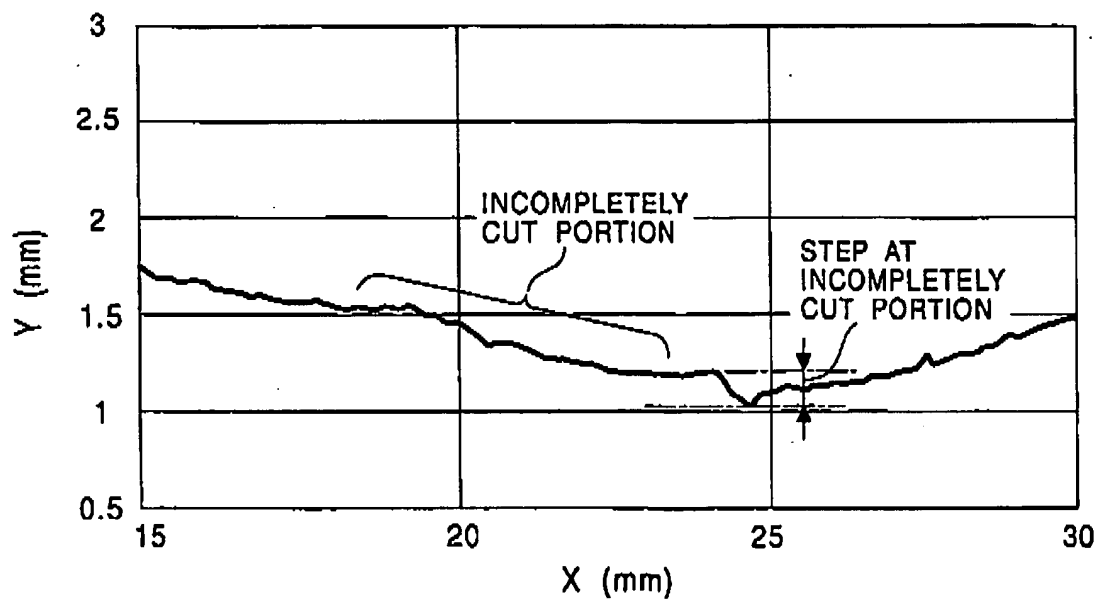


FIG. 10

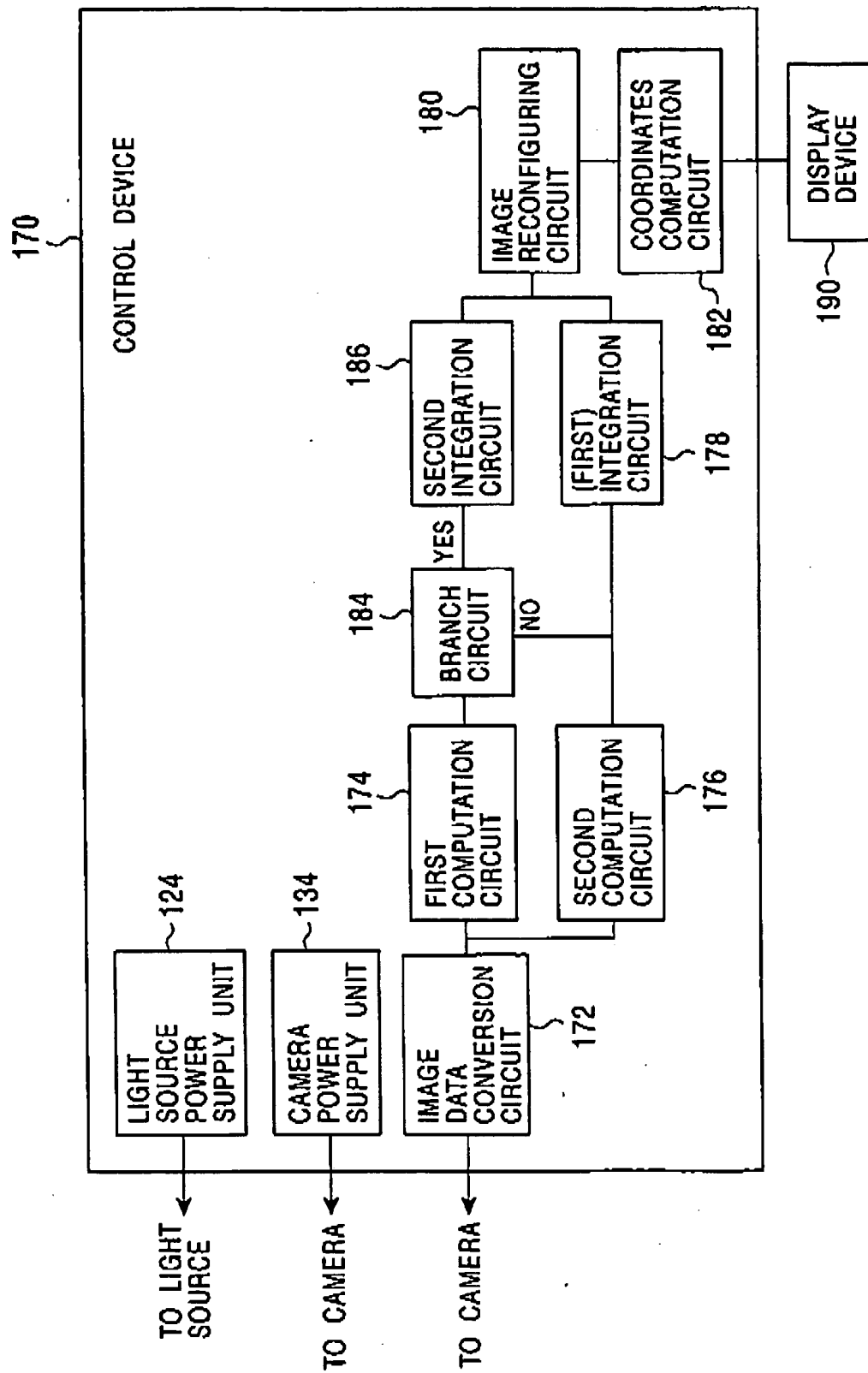


FIG. 11

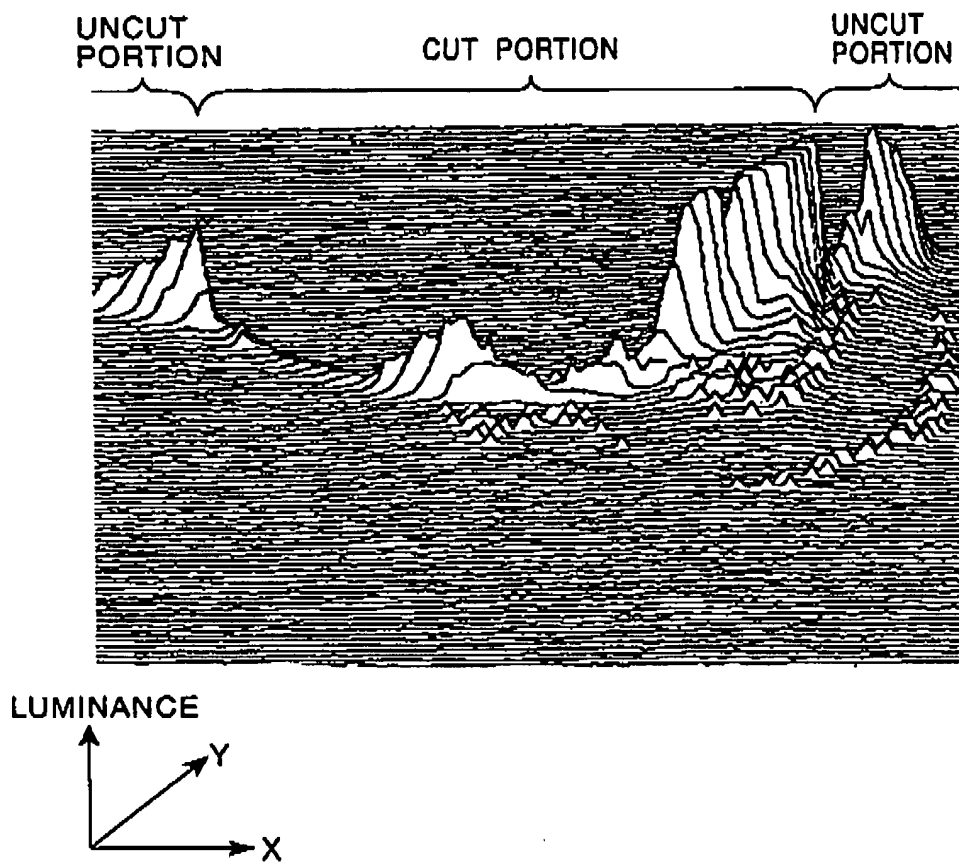


FIG. 12

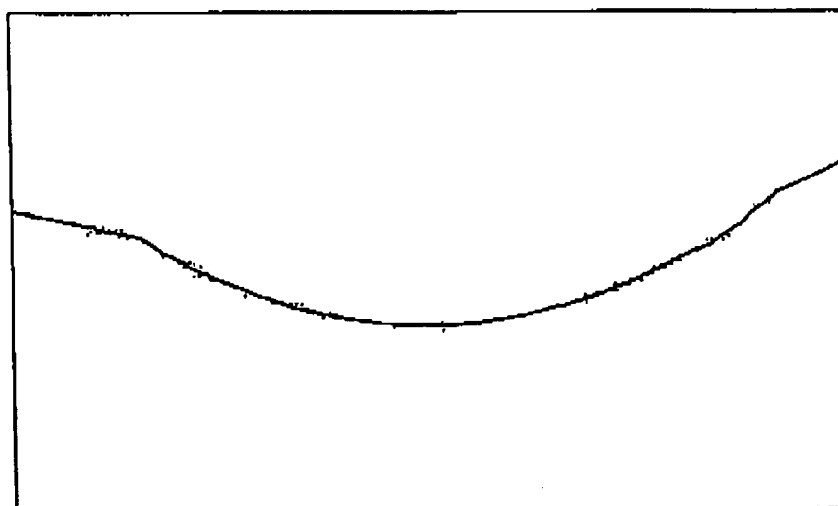


FIG. 13

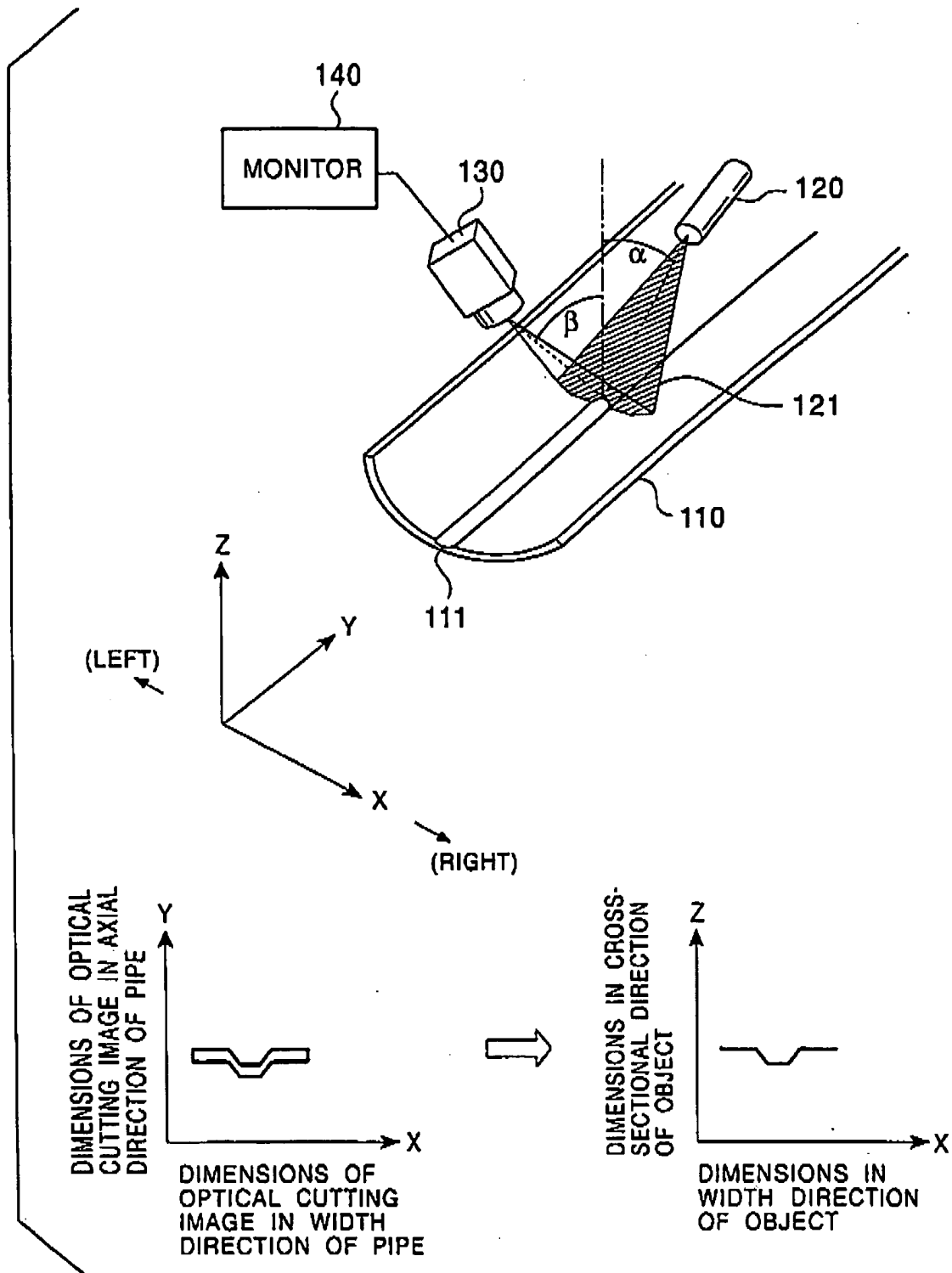


FIG. 14

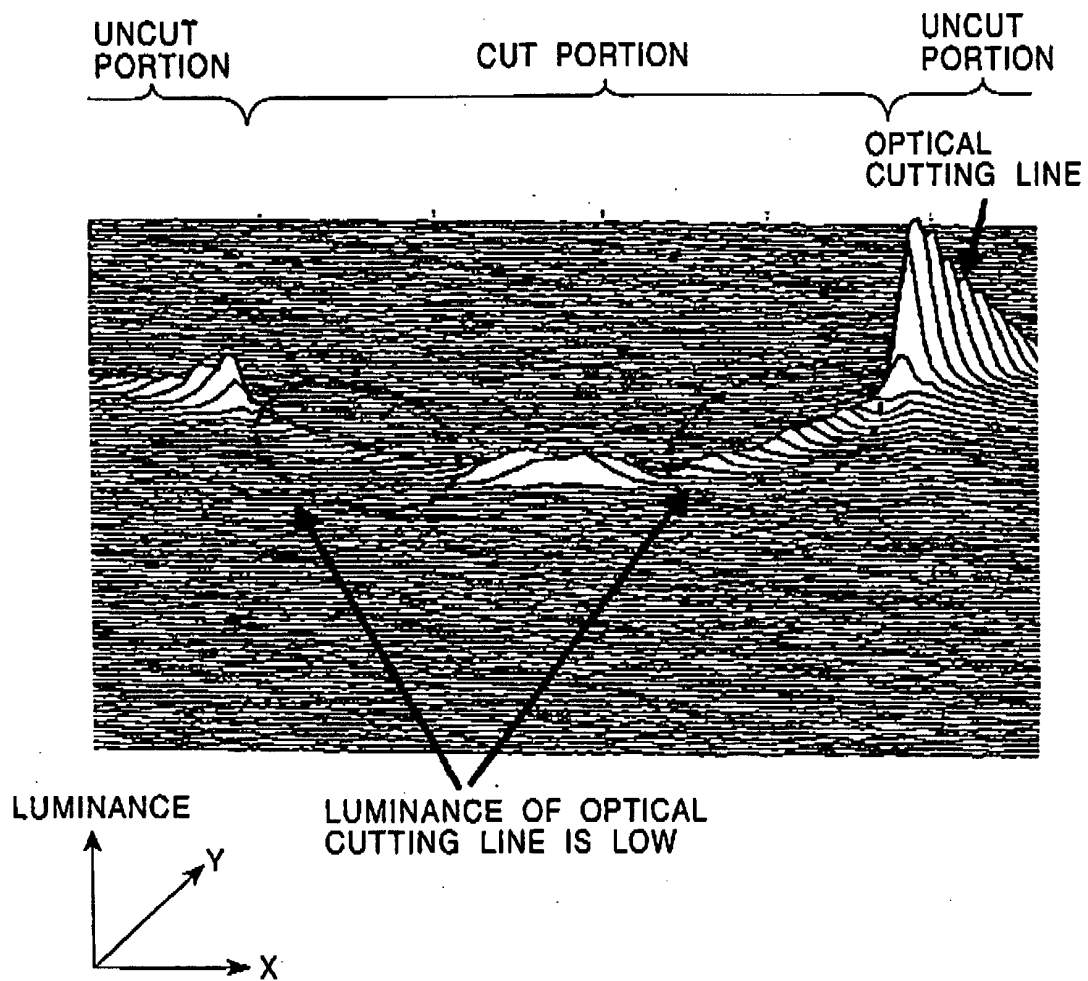


FIG. 15

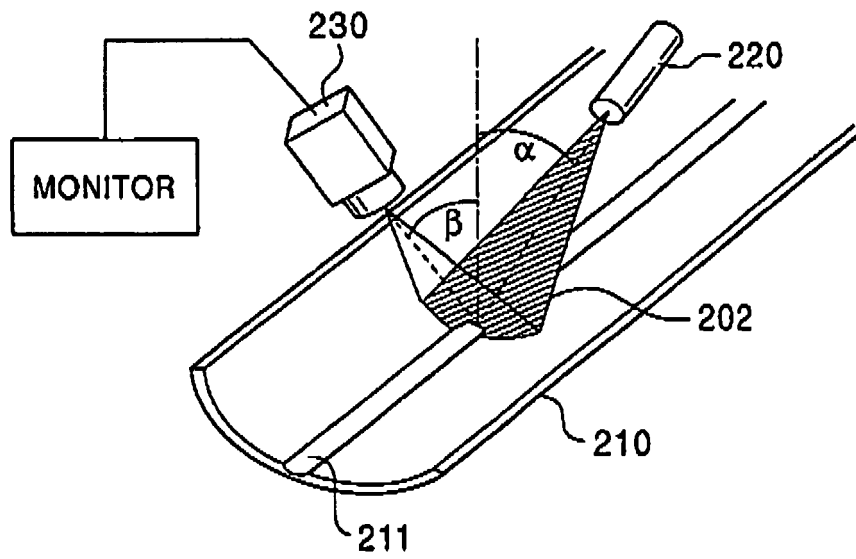


FIG. 16

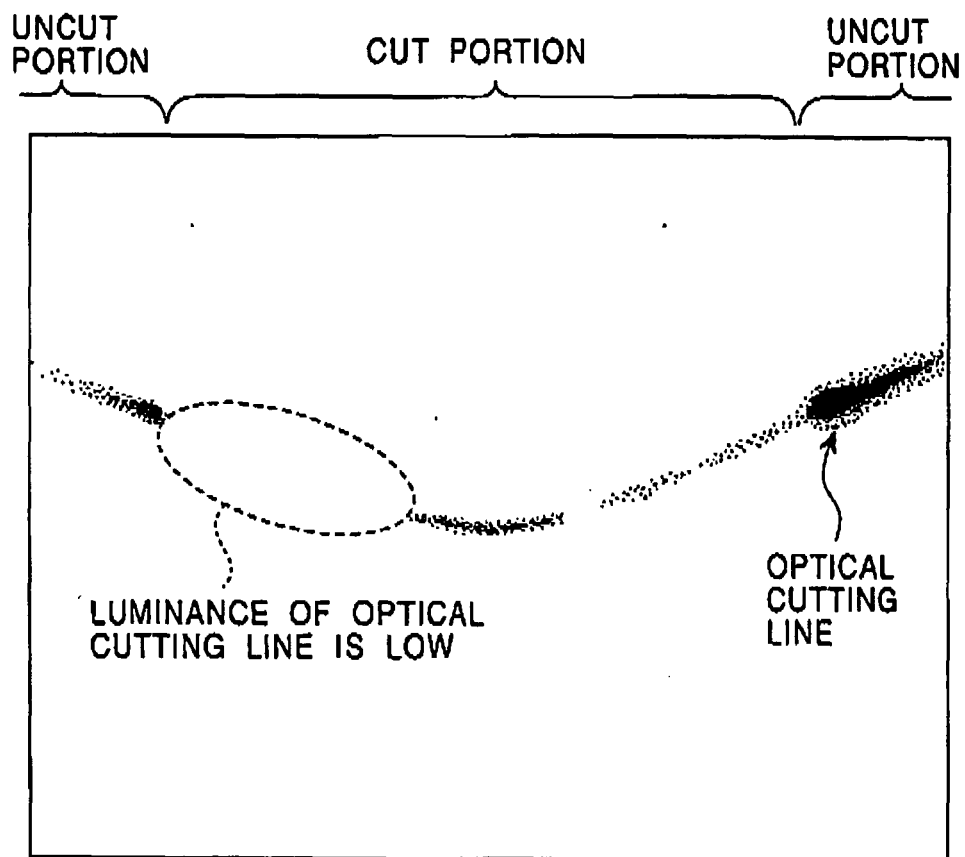
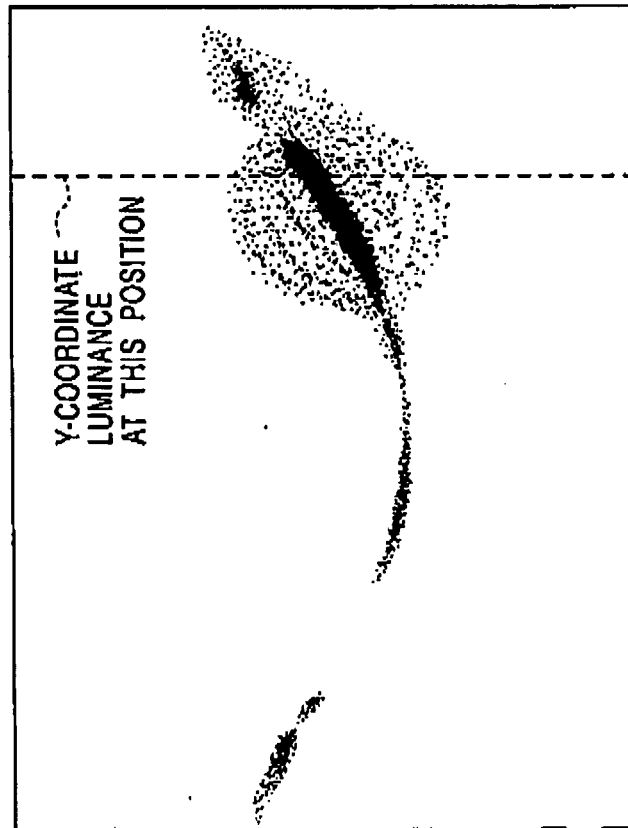
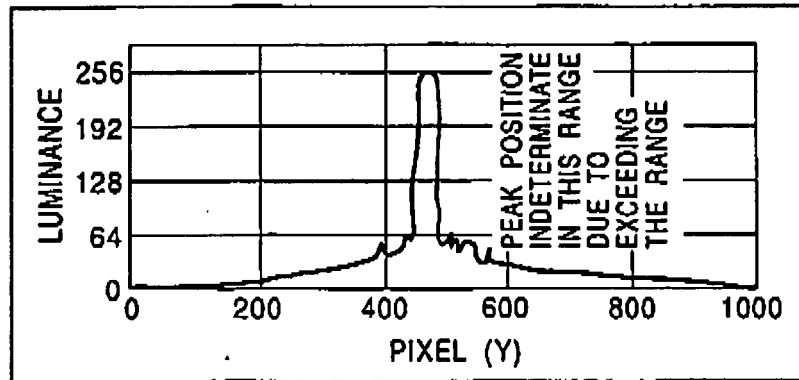


FIG. 17



REFERENCES CITED IN THE DESCRIPTION

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